while heating the SOG layer that made of HSQ (Hydrogen silsesquioxan) at a temperature from a normal temperature to about 500℃.

In the present embodiment, as described later in detail, in a method for forming an insulation film in which the heat treatment step is combined with the electron beam irradiation treatment step, at least one of a plurality of predetermined parameters is changed during the electron beam irradiation of the electron beam irradiation treatment step.

The plurality of predetermined parameters include pressure in a reactor chamber, temperature of the substrate, type of gas having the substrate exposed thereto, flow rate of gas introduced into the reactor chamber, position of the substrate, and quantity of electrons incident to the substrate per unit time.

That is, the inventors found out a method for changing at least one of a plurality of predetermined parameters, thereby easily obtaining an insulation film with its low dielectric rate having excellent crack resistance properties and excellent durability in processes such as dry etching, dry icing, CMP, or the like.

The method according to the present embodiment is significantly different from methods disclosed in the previously described PCT National Publication HEI No. 11-505670, PCT National Publication HEI

No. 11-506872, and Jpn. Pat. Appln. KOKAI Publication No. 10-107026 or the like in that predetermined parameters are thus changed during the electron beam irradiation treatment.

Further, as described below in detail, in a chamber that is the same as a reactor chamber for carrying out the electron beam irradiation treatment, at least one of pre-heat treatment and post-heat treatment may be carried out continuously together with the above coat film process. The above pre-heat treatment and post-heat treatment are accompanied by a change in at least one or more of a plurality of predetermined parameters.

The plurality of parameters includes pressure in the reactor chamber, temperature of the substrate, type of gas having the substrate exposed thereto, flow rate of the gas introduced into the reactor chamber, and position of the substrate.

The method according to the present embodiment is significantly different from methods disclosed in the previously described PCT National Publication HEI No. 10-505670, PCT National Publication HEI No. 11-506872, and Jpn. Pat. Appln. KOKAI Publication No. 10-107026 or the like in that the pre-heat treatment or post-heat treatment that is continuous carried out with the above electron beam irradiation, and the at least one parameters is changed during these

treatments in a chamber that is the same as a reactor chamber for carrying out the electron beam irradiation treatment.

The cutting of a molecule chain of the film material or separation of groups occurs due to the electron beam irradiation. Further, bridge reaction is accelerated by heat treatment using the electron beam irradiation in combination, and a relationship between cutting and separation due to the electron beam irradiation is harmonized. As a result, a network structure with its high mechanical strength is produced in the film material, and crack resistance properties of the insulation film with its low dielectric rate is improved.

In the electron beam irradiation step, it is important to irradiate the inside of the film material with the electron beam of their proper dose so that the cutting of molecule chain or separation of groups that occurs at the same time as bridge is prevented from being excessively accelerated.

In the case of many coating materials, heat treatment is carried out prior to the electron beam irradiation treatment, and the film material due to solvent evaporation is actively solidified, whereby a better insulation film can often be formed.

Now, embodiments of the present invention will be described with reference to the accompanying drawings.